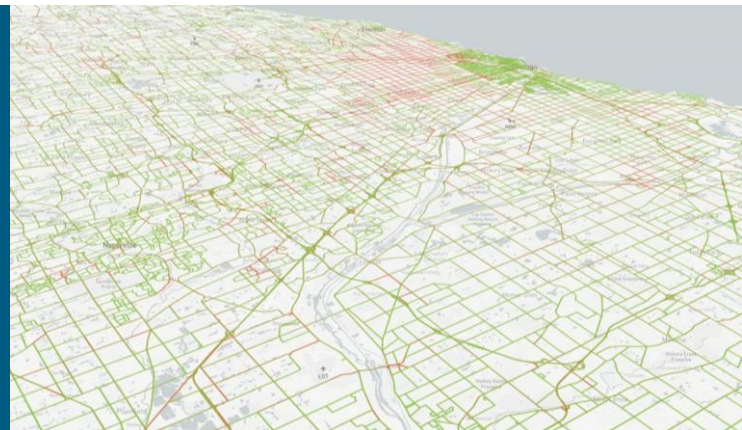


JUNE 01-04, 2020



# SYSTEMS AND MODELING FOR ACCELERATED RESEARCH IN TRANSPORTATION (SMART) MOBILITY CONSORTIUM TOOLS AND PROCESS DEVELOPMENT



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Vehicle and Mobility Systems Group

Argonne National Laboratory

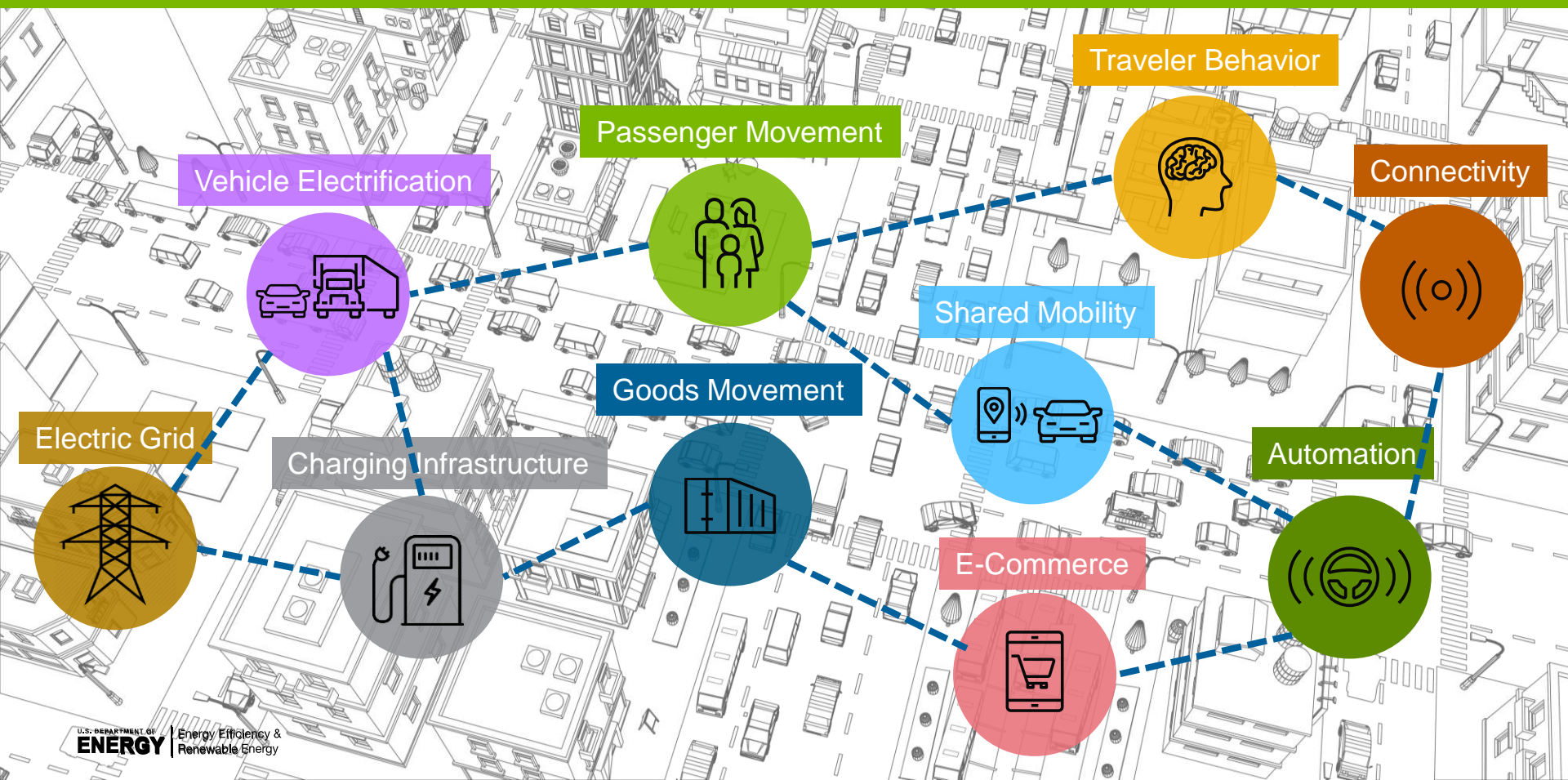
**Project ID# EEMS0058**

**This presentation does not contain any proprietary, confidential, or otherwise restricted information**

# PROJECT OVERVIEW

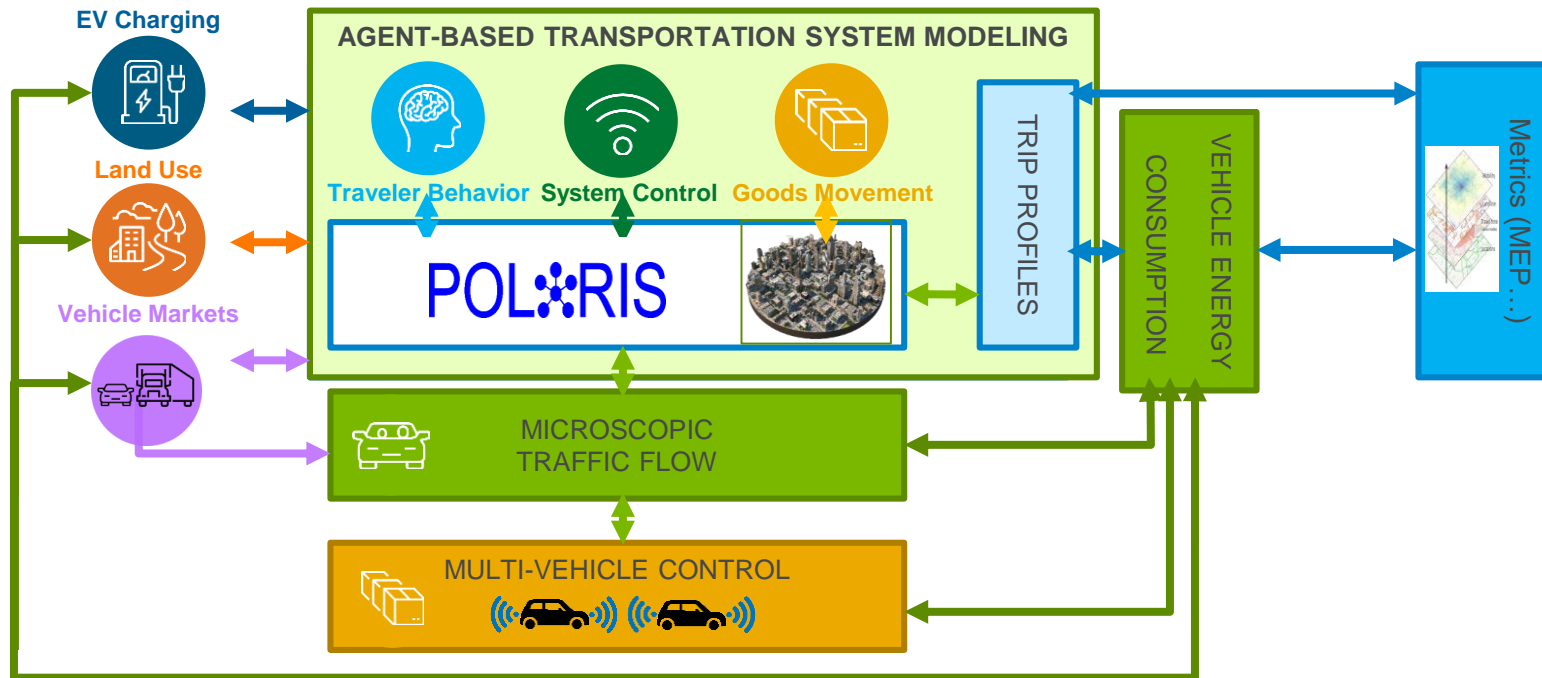
Timeline	Barriers
<ul style="list-style-type: none"> <li>Project start date : Oct. 2018</li> <li>Project end date : Sep. 2019</li> <li>Percent complete : 100%</li> </ul>	<ul style="list-style-type: none"> <li>High uncertainty in technology deployment, functionality, usage, impact at system level</li> <li>Computational models, design and simulation methodologies</li> <li>Integration of many model frameworks: land use, demand, flow, vehicles, grid, economy</li> </ul>
Budget	Partners
<ul style="list-style-type: none"> <li>FY19 Funding Received : \$1,000,000</li> </ul>	<ul style="list-style-type: none"> <li>Argonne (Lead)</li> <li>LBNL, NREL, ORNL, INL, LLNL</li> <li>Universities (UCI, GMU, UIC, Texas A&amp;M, Texas At Austin, UNSW, Washington)</li> </ul>

# Relevance: Transportation System is Being Disrupted

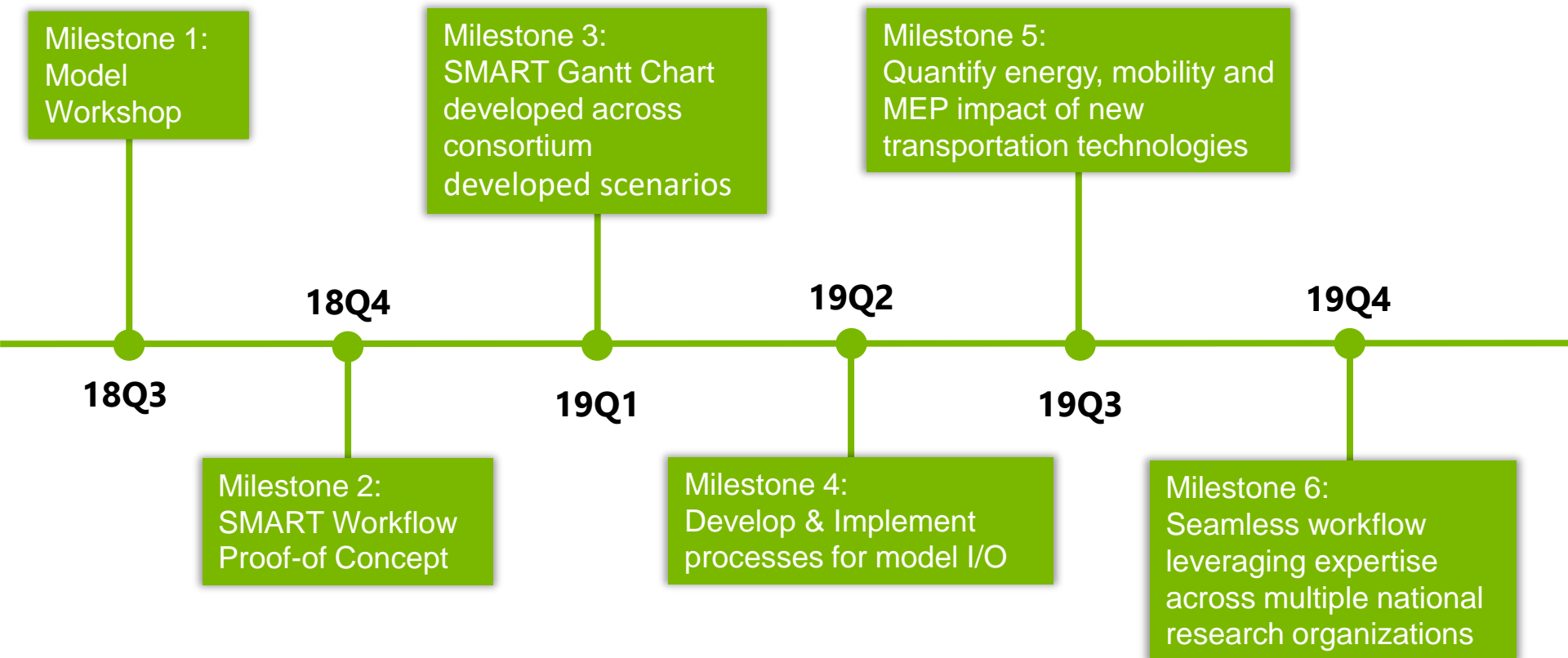


# APPROACH

## Answer Complex Questions through High Fidelity System Simulation



# MILESTONES





# TECHNICAL ACCOMPLISHMENTS

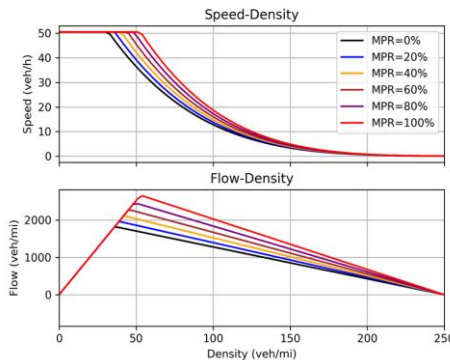
- **Enhanced model fidelity**
- **Connected models**
- **Migrated workflow to HPC**
- **Validated POLARIS (current & past)**
- **Defined future scenarios**
- **Exercised the workflow**

# LEARNING FROM DETAILED MODELS TO SCALE TO LARGER ONES

## Microsimulation

Freeway corridor with different level market penetration of CAVs

## Fundamental Diagram POLARIS Input



## Mesosimulation



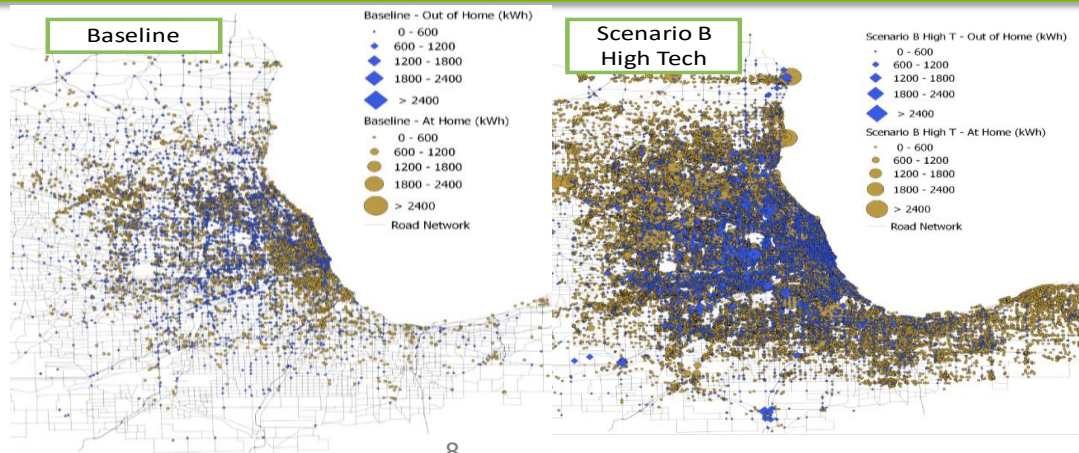
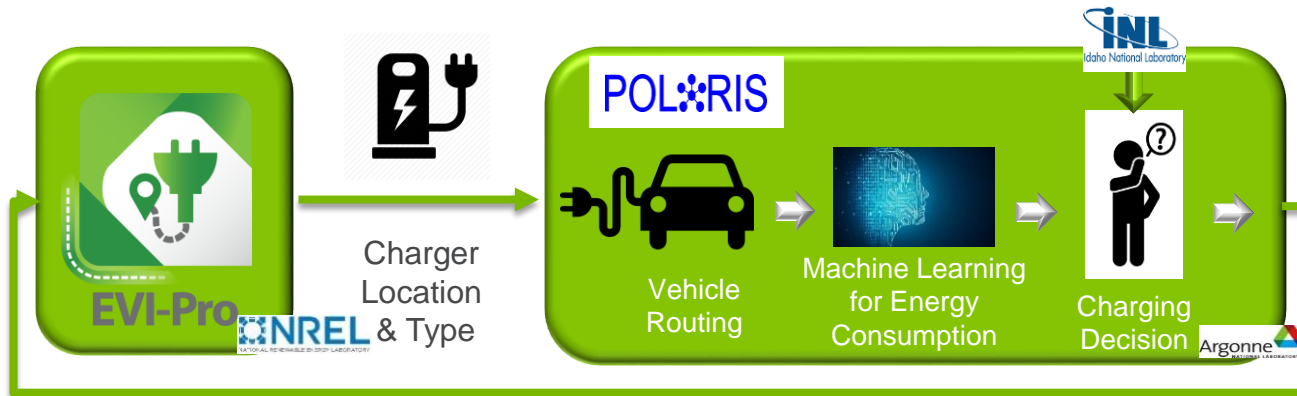
Parameters

Model & calibration improvement

→ Current  
- - - - - Future

Note: Any proposed future work is subject to change based on funding levels.

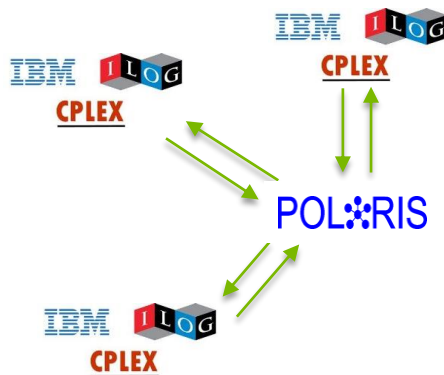
# PEV CHARGING LOCATION AND BEHAVIOR



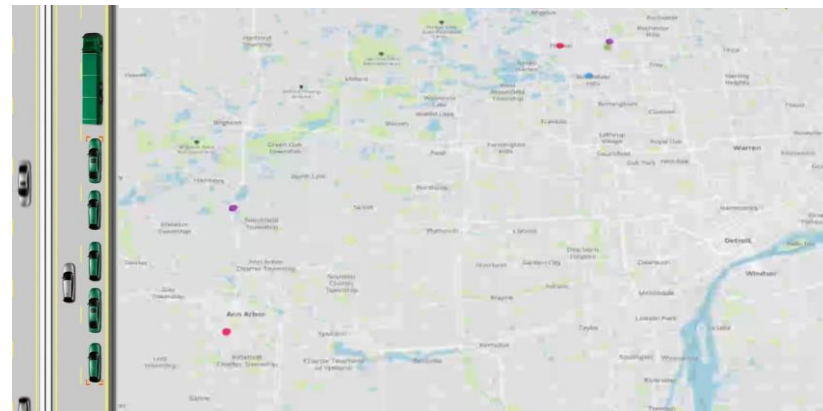


# HPC ENABLES OPTIMIZATION & CONTROL

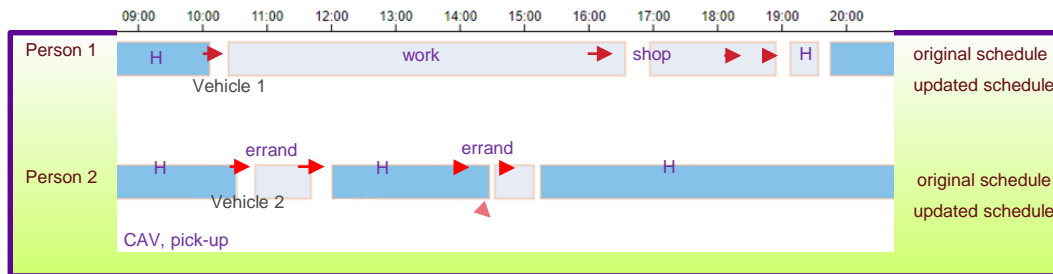
Implemented processes to efficiently link to external optimization tools



## Example: Platoon Formation Decision



## Example: Personally Owned AVs



# WORKFLOW IMPLEMENTATION USING POLARIS IS UNIQUE

## POLARIS

### ■ Key modeling features:

- Full-featured **activity-based** model
- **Integrated** demand, network assignment and traffic flow
- Includes **freight** shipments and local deliveries
- Traveler behavior impacts of **VOTT** across many choices
- High-fidelity **vehicle energy** consumption
- **EV charging** and **grid** integration
- Connection to **UrbanSIM** land use

### Computational performance:

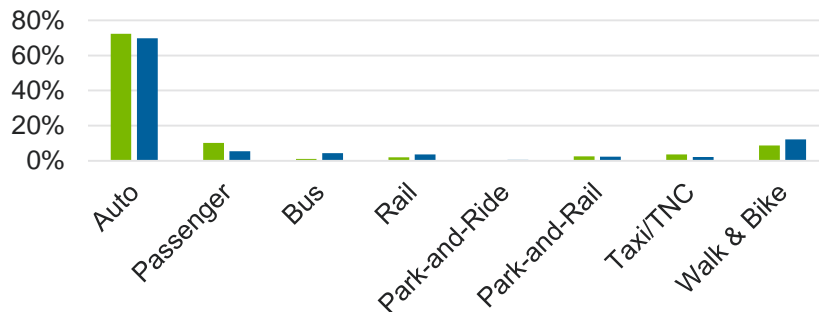
- Fully **agent-based**
- Large-scale models with **100% of agents**
- High-performance **C++ codebase**
- **4-6 hr runtime** for up to 10 million agents
- Cross-platform implementation can run on Linux **HPC** clusters
- Integration with external **optimization** solvers (CPLEX, Gurobi, GLPK)

# VALIDATION

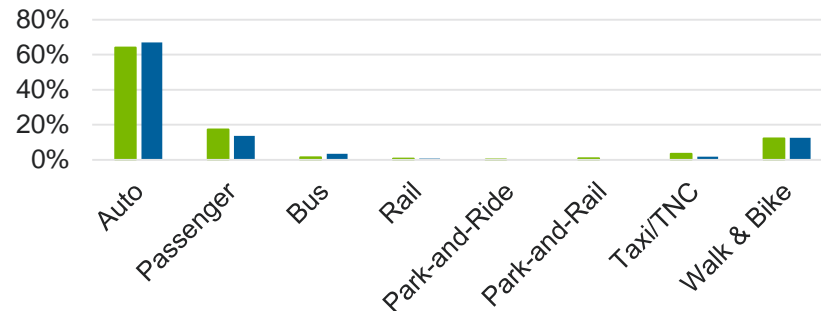
## Individual Mode Choices against CMAP<sup>(1)</sup> Survey

### Work trips

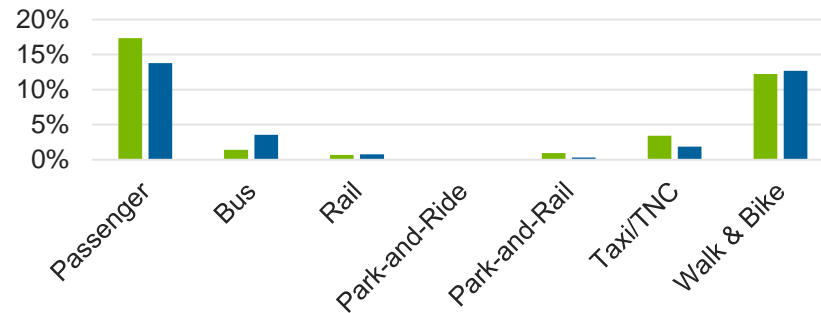
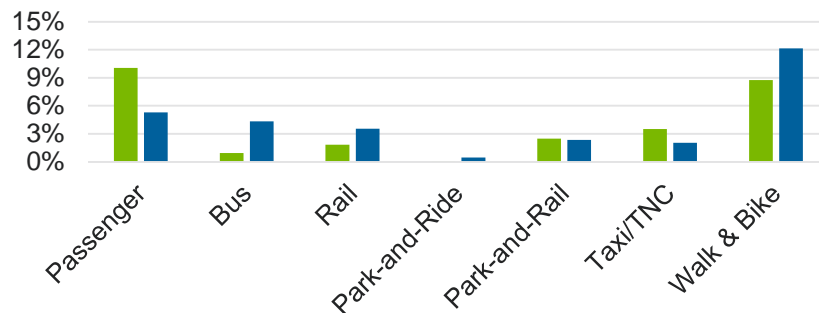
All modes



### Non-Work trips

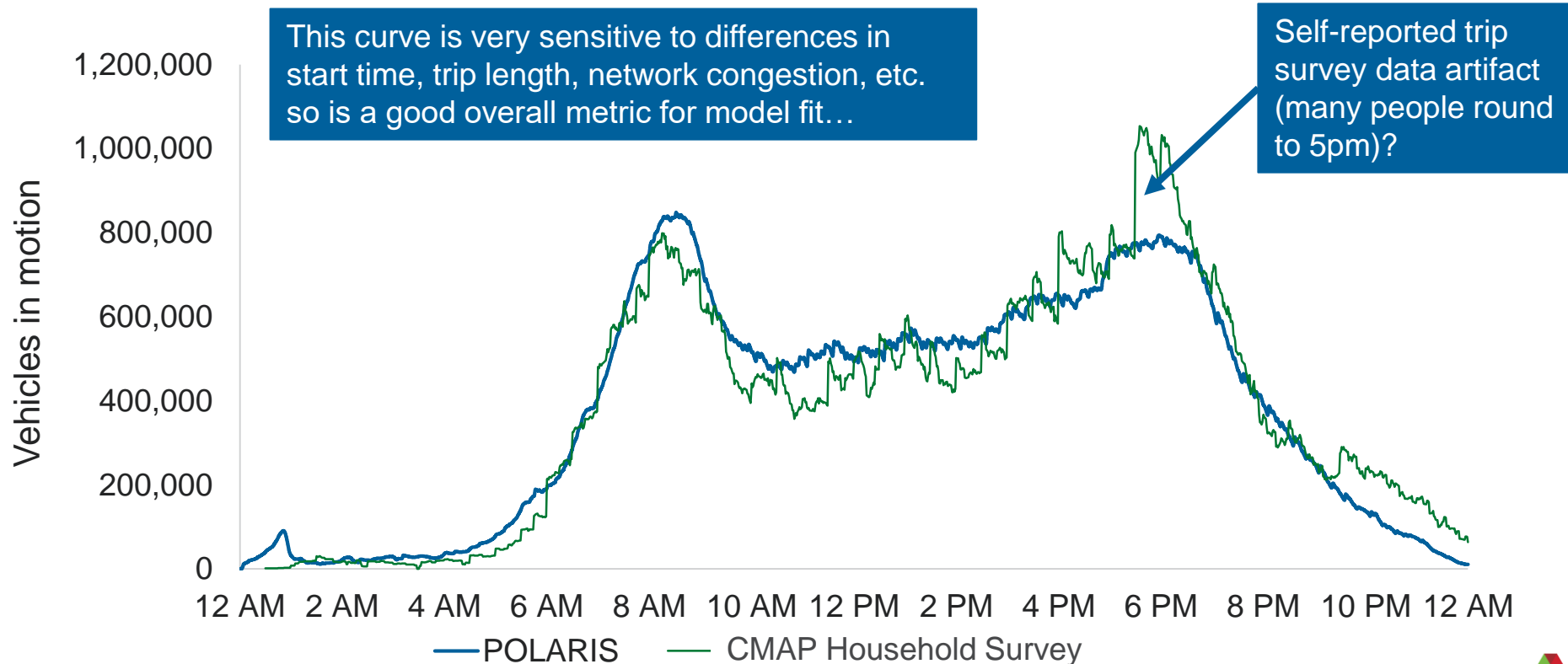


Non-auto modes



# VALIDATION




## Total Vehicle Load on the System Matches CMAP Survey Data





# BACK CASTING VALIDATION

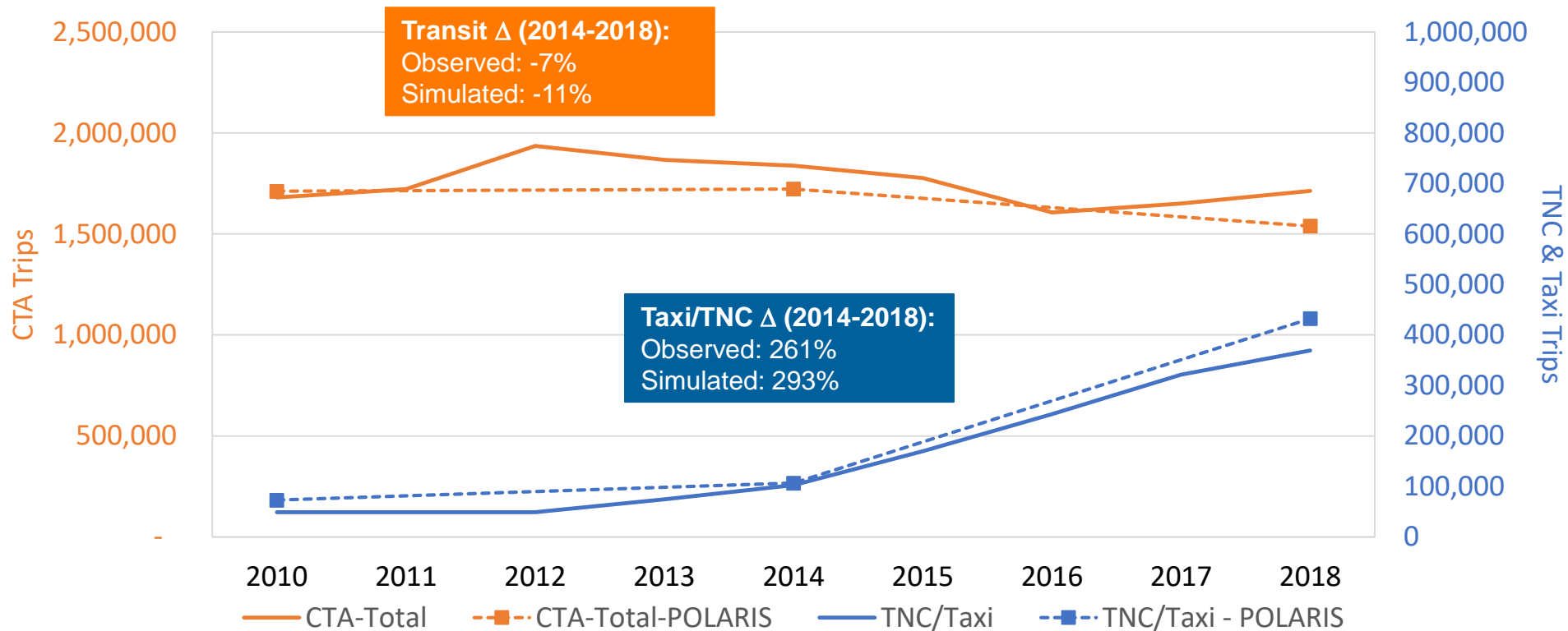
## Scenarios Differ only in TNC/Taxi Characteristics

Scenario Parameters	2010 	2014 	2018 
Fleet size	3,000	10,000	48,000
Service area	Chicago & inner suburbs	Whole metro area	Whole metro area
Avg. wait time	12 minutes	12 minutes	6 minutes
Per mile cost	\$1.80	\$1.50	\$1.25

Sources: [data.cityofchicago.org/browse?category=Transportation](https://data.cityofchicago.org/browse?category=Transportation);

# BACK CASTING VALIDATION

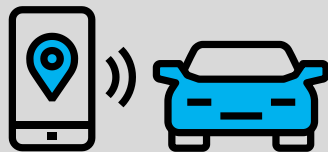
Transit (Bus + Train) declines slightly as TNC grows substantially



# FORECASTING SCENARIOS CONSIDERED

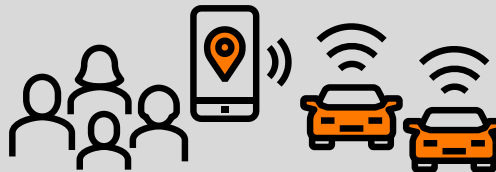
## A world of

### HIGH SHARING, PARTIAL AUTOMATION (Sharing)



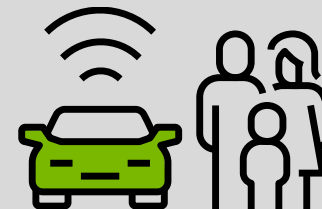
New technology enables people to significantly increase the use of **transit, ride-hailing** and **multi-modal travel**. **Partial automation** is introduced and is primarily used on the highway.

### HIGH SHARING, HIGH AUTOMATION (SAV)



Technology has taken over our lives, enabling **high usage of fully automated driverless vehicles, ride-hailing** and **multi-modal trips**, which are convenient and inexpensive. As a result, **private ownership has decreased** and **e-commerce has increased**.

### LOW SHARING, HIGH AUTOMATION (Private-AV)



**Fully automated privately owned driverless vehicles** dominate the market. The ability to own AVs leads to **low ride-sharing** and an expansion of urban/sub-urban boundaries, while **e-commerce has increased**.

# SHARED FLEET CAVS ENABLE HIGH SYSTEM EFFICIENCY

Compared to personally owned CAVs



CHICAGO

HIGH SHARING,  
HIGH AUTOMATION (SAV)



**23%**  
Energy

**18%**  
VMT

**0%**  
PMT

**17%**  
Speed

**22%**  
Energy

**25%**  
VMT

**7%**  
PMT



**18%**  
Speed

LOW SHARING,  
HIGH AUTOMATION (Private-AV)



# INCREASE IN E-COMMERCE LOWERS OVERALL SYSTEM VMT AND ENERGY

Fewer shopping trips, more deliveries make the difference

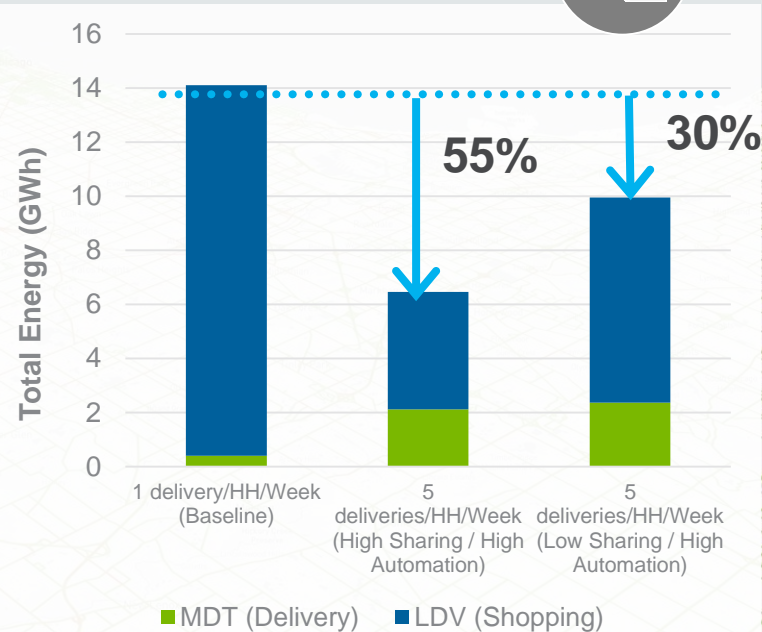
## CHICAGO

SHOPPING TRIP = 7 to 8 miles, each way



## DELIVERY TRIP

1 ADDED STOP = 0.4 mile



# RESPONSE TO PREVIOUS YEAR REVIEWERS' COMMENTS

Reviewer Comment	Answer
Specific details of each product covered by the project should be explained. In addition, the reasons why these products are chosen for development should be explained	Detailed description of the tools and the workflow is available in the SMART Mobility Workflow Capstone report
The reviewer also strongly endorsed the suggestion to model the same city with both POLARIS and BEAM to compare results with the primary goal of comparing and improving each model	The models for two metropolitan areas (Detroit and Austin) are currently being developed with both tools
The reviewer suggested considering validation of simulation model in the different environments	Additional validation and back casting was performed with POLARIS

# PARTNERSHIPS AND COLLABORATIONS



EEMS013, EEMS016, EEMS017, EEMS020, EEMS023, EEMS031, EEMS034, EEMS035, EEMS057, EEMS060, EEMS068, EEMS075, EEMS076, EEMS077, EEMS078, EEMS079



Improvement of CAV traffic flow model using CAV-specific fundamental diagrams



Shared Automated Vehicle (SAV) fleet modeling



Traveler behavior – Value of Travel Time



Activity scheduling and resource allocation



TNC modeling



Real-world vehicle energy use used to develop the Machine Learning Model

# REMAINING CHALLENGES AND BARRIERS

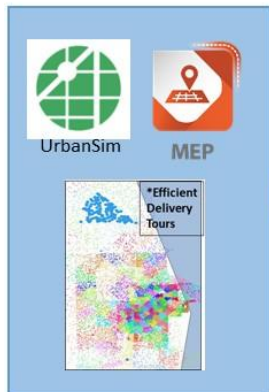


- Numerous manual steps, which required coordination amongst staff from multiple National Laboratories to manually launch their processes and transfer data back and forth
- Lack of robust user interfaces for efficient simulation setup and analysis
- Ad-hoc, file-based connections between many tools
- Computational barriers and inefficiencies in many tools
- Lack of common post-processing tools to quickly and consistently analyze results and perform quality check
- Limited validation, calibration of stand-alone tools and no calibration for joint process



# PROPOSED FUTURE RESEARCH

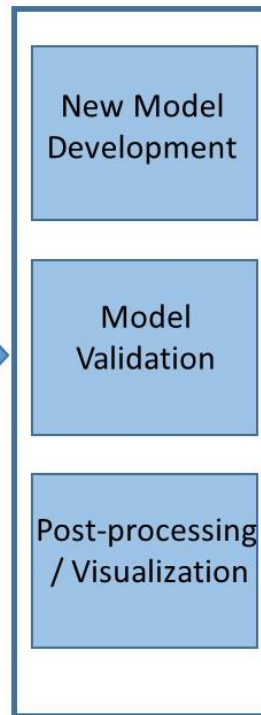
## Improve Existing Linkages



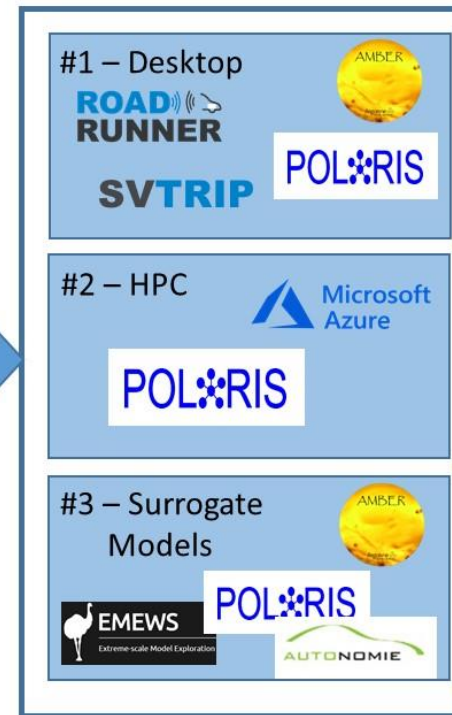
## Automate Existing Model Linkages



## Automate Existing Process



## Deploy to Stakeholders



Note: Any proposed future work is subject to change based on funding levels.

# SUMMARY – UNIQUE CAPABILITIES



- Developed a unique workflow to estimate the impact of new technologies on mobility, energy, cost, GHG...

## Integrated

- >10 partners
- > 12 tools
- VTO Benefit/Targets  
Includes economic impact
- Linkage with Life Cycle Analysis tools (GREET)

## High Fidelity

- 100% agents simulated
- Passenger and freight movement
- Travel behavior
- Includes stop signs & traffic lights
- Enables vehicle speed dynamic
- Accurate energy consumption
- Component operating conditions

## Computationally Efficient

- ~4h for 10M agents
- Entire process deployed with HPC

- Validated POLARIS for current and previous scenarios to increase forecasting confidence
- Exercised workflow on multiple future scenarios

For any questions, please contact:  
Aymeric Rousseau (arousseau@anl.gov)



U.S. DEPARTMENT OF ENERGY

# SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation